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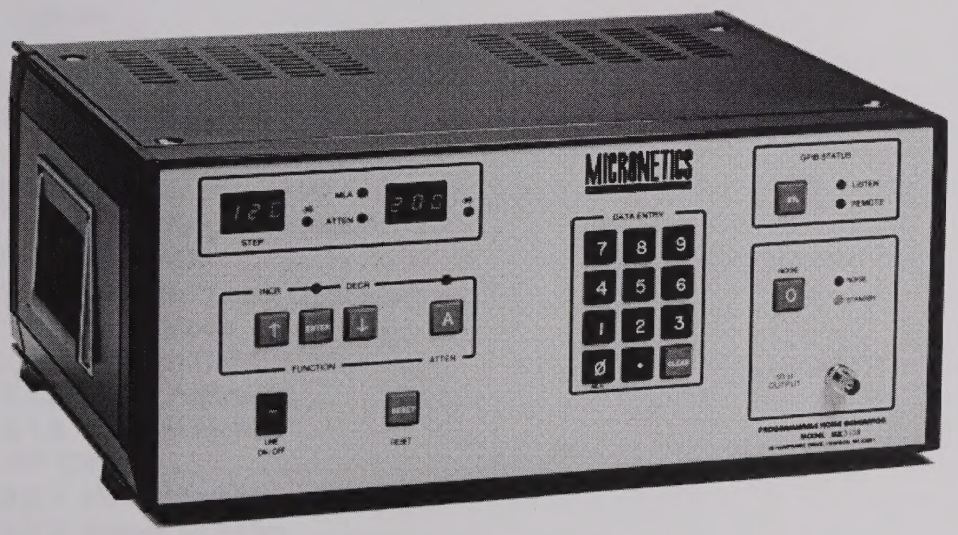

MX 5000 Series
Noise Generator

OPERATING MANUAL

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1.0 Introduction

1.1 Introduction

MX 5000 Series is a family of microprocessor-based, solid state, programmable high level noise instruments. The series features fifteen models covering a frequency range from 10 Hz to 18 GHz.

Standard noise output level is (+10) dBm; (10 mW); over the frequency range of each model. Optionally 0 dBm; 1 mW; and +30 dBm; 1 W; output levels are available. Table 1 lists the models and their respective frequency, flatness and VSWR characteristics.

The instruments are ideal sources of real-world signals and facilitate broadband measurements with a single source. This reduces testing time and eliminates errors in measurements due to generator switching, test set-up changes, calibration correlation and terminating impedance's, as reconnections are made between different instruments. The noise instrument generates white noise, i.e. electrical noise displaying equal energy per cycle over a specified total frequency band. Further, the generator noise is random. An infinite collection of frequencies produce instantaneous peaks of randomly varying amplitudes.

The whiteness and randomness combined with a high crest factor (peak to rms ratio 5:1 min) represents a real world signal, which is used as a stimulus to the system under test.

In the field of test and measurement, the demand for automated test systems has gained the IEEE-STD-488 (GPIB); digital interface for programmable instruments; widespread implementation. The MX-5000 Series implements the IEEE-STD-488 as a standard feature. All front panel controls, except AC power on/off, and several additional functions can be remotely programmed via the GPIB.

Table 1: MX 5000 Model vs Electrical Characteristics

Model Number	Frequency Range	Flatness	VRWR
MX - 5101	10 Hz - 20 KHz	± 0.5 dB	1.5:1
MX - 5102	10 Hz - 100 KHz	± 0.5 dB	1.5:1
MX - 5103	10 Hz - 500 KHz	± 0.5 dB	1.5:1
MX - 5104	100 Hz - 3 MHz	± 0.5 dB	1.5:1
MX - 5105	100 Hz - 10 MHz	± 0.75 dB	1.5:1
MX - 5106	100 Hz - 25 MHz	± 1.0 dB	1.5:1
MX - 5107	100 Hz - 100 MHz	± 1.0 dB	1.5:1
MX - 5108	100 Hz - 300 MHz	± 1.0 dB	1.5:1

Table 1: MX 5000 Model vs Electrical Characteristics

Model Number	Frequency Range	Flatness	VRWR
MX - 5109	100 Hz - 500 MHz	± 1.5 dB	1.5:1
MX - 5110	300 MHz - 1 GHz	± 2.0 dB	1.5:1
MX - 5111	1 GHz - 2 GHz	± 2.0 dB	2.0:1
MX - 5112	1 MHz - 2 GHz	± 2.0 dB	2.0:1
MX - 5200	100 Hz - 1 GHz	± 2.0 dB	2.0:1
MX - 5250	100 Hz - 1.5 GHz	± 2.5 dB	2.0:1
MX - 5300	2 GHz - 18 GHz (-10 dBm)	± 3.0 dB	2.5:1

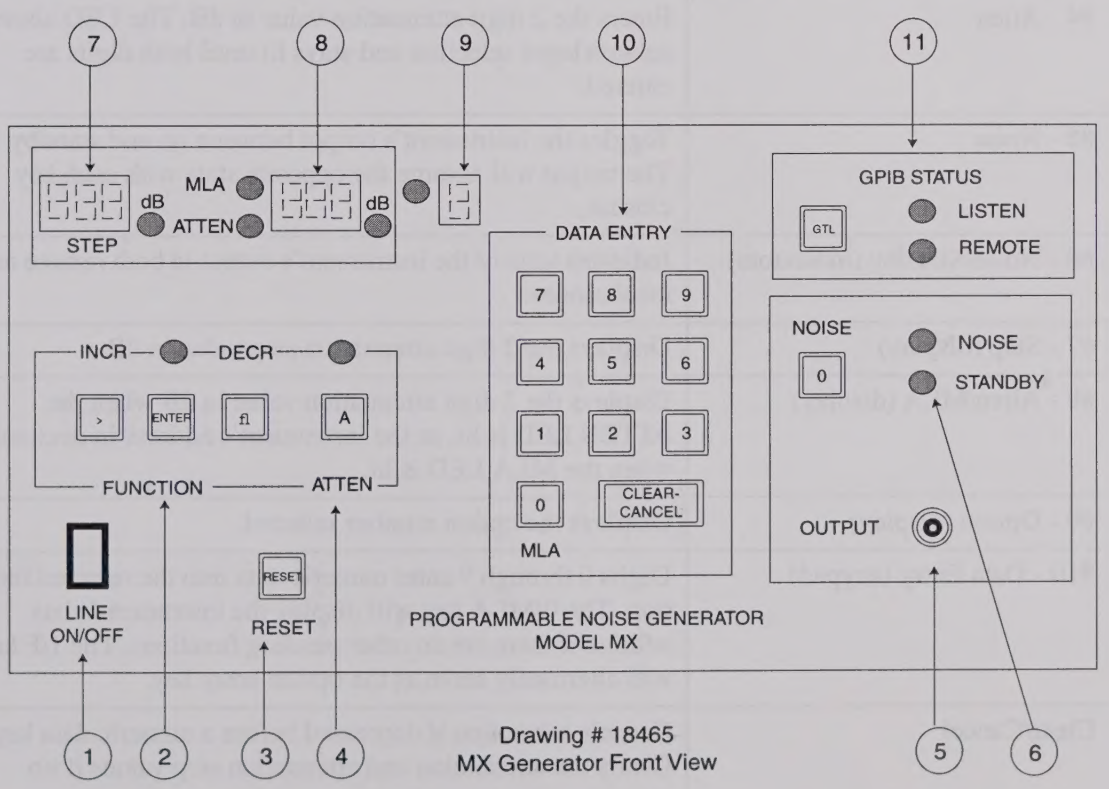
2.0 General Description

2.1 Introduction

The MX-5000 series generator is a self-contained, compact instrument suitable for bench-top or rack mounted use. The enclosure is aluminum with textured black vinyl finish. The top and bottom panels are vented for proper thermal management. Rack mounting brackets with pull handles are provided for 19 inch rack mounting. Swing out type handles enhances portability.

2.2 Front Panel

The front panel features a partitioned layout to facilitate familiarization and use of the instrument. Function entry keys are color coded for easier identification. Displays and LED's provide a visual verification of the instruments status. The rear panel serves as a mounting for the AC receptacle / filter, fuseholder, 110/220 voltage selector, instrument address switches, the GPIB connector and the cooling fan.



Drawing # 18465
MX Generator Front View

2.2.1 Description of Front Panel Components

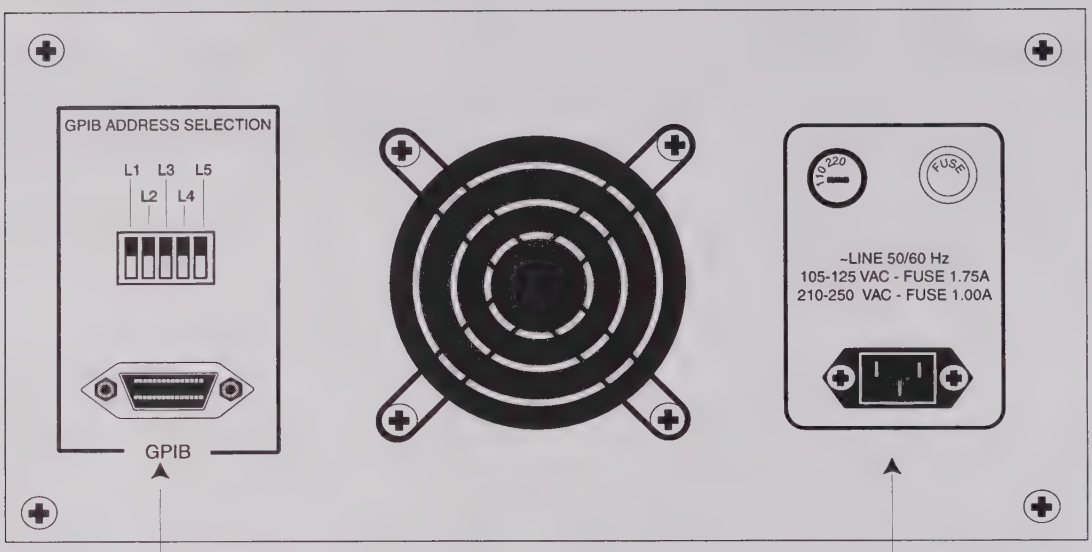
Table 2: MX Front Panel Components

Description	Function
#1 - Line On/Off	Controls application of the power to the instrument. Illuminates when ON.
#2 - Enter	Enters the 2 digit attenuation step value in dB. The LED above acknowledges selection and stays lit until both digits are entered.
Incr	Increments the attenuator by the step value.
Decr	Decrements the attenuator by the step value.
#3 - Reset	Forces the instrument through a master reset. Self tests and initialization routines are performed.
#4 - Atten	Enters the 2 digit attenuation value in dB. The LED above acknowleges selection and stays lit until both digits are entered.
#5 - Noise	Toggles the instrument's output between on and standby. The output will assume the opposite state with each key closure.
#6 - Noise/Standby (indicators)	Indicates state of the instrument's output in both remote and local modes.
#7 - Step (display)	Displays the 2 digit attenuation step value in dB.
#8 - Atten/MLA (display)	Displays the 2 digit attenuation value in dB when the ATTEN LED is lit, or the instrument's address in decimal when the MLA LED is lit.
#9 - Option (display)	Displays the option number selected.
#10 - Data Entry (keypad)	Digits 0 through 9 enter numeric data into the selected function. The 0/MLA key will display the instrument's bus address if there are no other pending functions. The 1/F key will alternately serve as the option entry key.
Clear/Cancel	Cancels a function if depressed before a numeric data key. Clears the attenuation and attenuation step values if no other function is pending.
#11 - GTL	Go to Local; returns the instrument to its local mode. The instrument stays in local mode until readdressed via the GPIB.

Table 2: MX Front Panel Components

Description	Function
Listen/Remote (Indicators)	Indicate the instrument's bus status. LISTEN is lit when the instrument recognizes its bus address. REMOTE is lit when the instrument is in remote mode.

2.3 Rear Panel



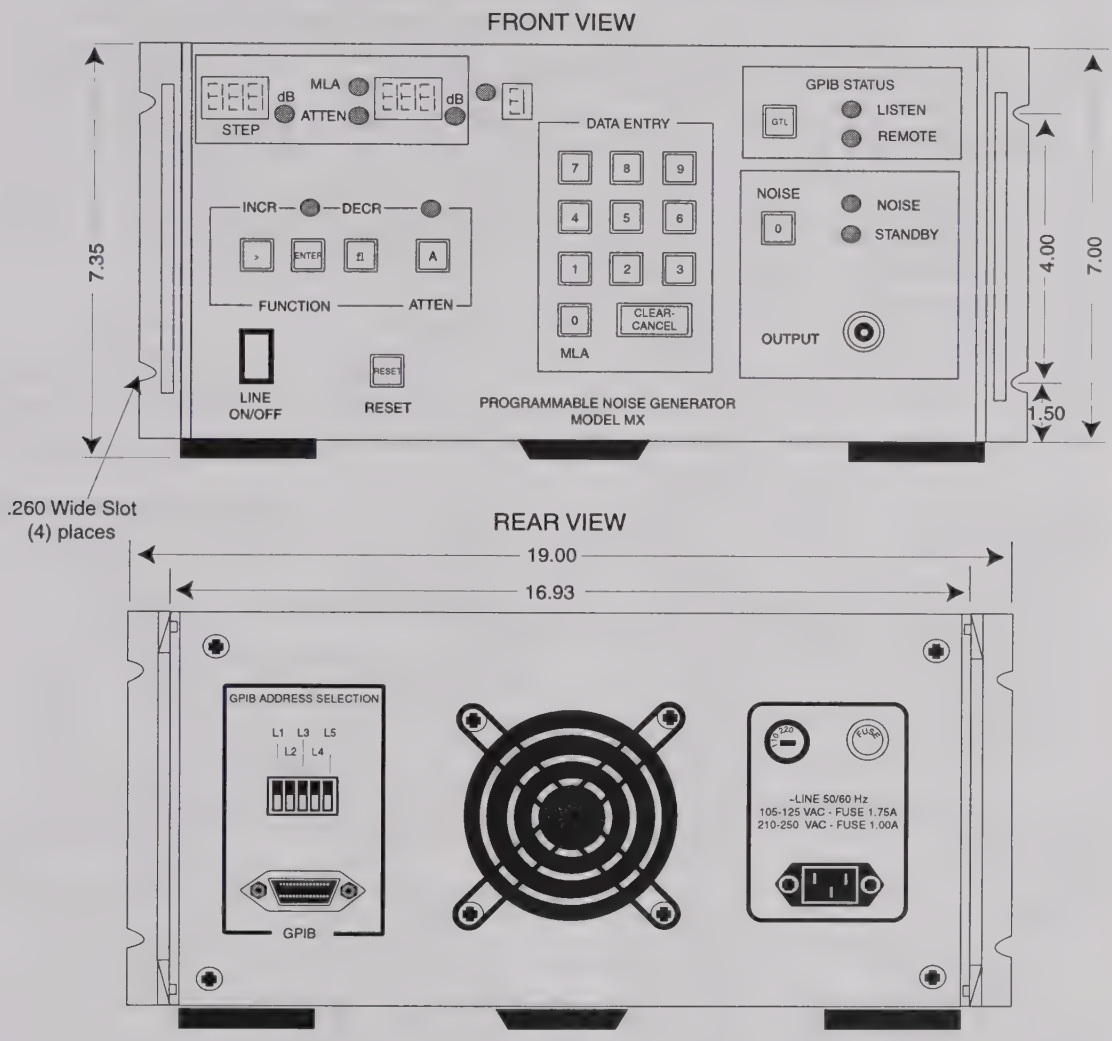
Drawing # 18468
MX Generator Rear View

2.3.1 Description of Rear Panel Components

Table 3: MX Rear Panel Components

Description	Function
#1 - Address Selection Switches	Selects the LISTEN ADDRESS that the instrument will recognize. Total of 31 addresses selectable.
GPIB Connector	Interfaces the instrument to the IEEE-488 bus. A 24 position trapezoidal polarized connector conforms to IEEE-STD-488, 1978.
#2 - AC	Provides connection for line power. Incorporates EMI filter. Offset pin connected to instrument's chassis.
Voltage Selector	Selects the voltage of the line power. The appropriate line fuse has to be installed.
Fuse	Provides overload protection. The proper value of fuse accommodating the line power has to be installed.

2.4 MX Generator Outline



SIDE VIEW WIDTH 14.68

Drawing # 18692
MX Generator Outline

2.5 Specifications for Standard Model

Table 4: General Specifications (standard model)

Noise Output	+10 dBm, 10 mW
Incremental Range	±0-99 dB (± 0.0 - 99.9 with 0.1 db step option)
Attenuation Range	0-99 dB in 1 dB steps (0.1 dB steps available)
Attenuation Control	Front panel data entry or GPIB
Output Impedance	50 ohms
Output Connector	N-type (f)
Output Control	Front panel pushbutton key control or GPIB. In local mode output toggles between 'standby' and 'on' with every key closure.
Standby Mode	75 dB isolation minimum
Operating Temperature	0° C to +65° C
Temperature Sensitivity	Less than 0.01 dB / ° C
Voltage Sensitivity	Less than 0.1 dB / % Voltage change
Power Requirements	115 VAC, 60 Hz, 1.75 A 220 VAC, 50 Hz, 1.0 A
Dimensions	16.88 W x 7.00 H x 12.70 D - 19.0 W with rack mounting brackets
Weight	Approximately 20 lbs.
Power Cord	Three conductor
Enclosure D11 - 35 RM	19.0 W x 3.5 H x 11.75 D
Display	2 digit attenuation display in dB (3 digit display available) 2 digit attenuation step display in dB (3 digit display available)
Indicator LED's	Listen, Remote, MLA, Entry for attenuation and step data, Output standby, Output on
Remote Control	IEEE-STD-488, 1978 GPIB bus compatible
Programming Configurations	SH0, AH1, T0, L2, RL2, PP0, DC2, DT1, C0, E1
Address	31 listen addresses, rear panel selectable
GPIB Connector	24 contact, trapezoidal polarized

Table 4: General Specifications (standard model)

Attenuator Specification	
Attenuation range	0-99 dB in 1 dB steps (0.1 dB steps available)
Frequency range	DC - 2 GHz
Accurancy range	DC - 2 GHz
Accuracy of Increm. atten.	DC - 0.5 GHz; ±0.2 dB or 1/2% whichever is greater 0.5 - 1.0 GHz; ±0.2 dB or 1% whichever is greater 1.0 - 2.0 GHz; ±0.3 dB or 2% whichever is greater
Monotonicity	DC to beyond 1.5 GHz
Switch life	10 million operations / cell
Switching speed	6 msec max
RF Switch Specifications	
Switch type	1 pole, 2 position
Operating mode	Latching with TTL control and indicator circuits
Frequency range	DC - 18 GHz
Isolation	DC - 3.0 GHz; 75 dB min
Insertion loss	DC - 3.0 GHz; 0.2 dB max
Switch life	1 million operations
Switching speed	6 msec typical

2.6 Options

Table 5: Options

Option #	Description
1	Noise Output: 0 dBm / bandwidth
2	Noise Output: 30 dBm / bandwidth
3	Attenuator: 0 - 100 dB in 10 dB steps
4	Attenuator: 0 - 110 dB in 1 dB steps
5	Marker input
6	Manual noise standby / on control
7	Remote noise standby / on control
8	BNC output connector
9	75 ohm output impedance (BNC connector only)
10	220 VAC, 50 Hz
11	Rack mounting, D11 - 35 RM enclosure
12	Attenuator 0 - 99 in 0.1 dB steps

2.7 IEEE-STD-488 Signal Lines

2.7.1 Interface Management

- 1. ATN (Attention) - Specifies how data on the DIO lines are to be interpreted. ATN true specifies an interface message or command, ATN false specifies a device dependent message.
- 2. EOI (End or Identify) - Indicates the end of a multiple byte message. Used for polling sequence together with ATN.
- 3. IFC (Interface Clear) - Places the interface system in an initial state.
- 4. REN (Remote Enable) - Enables bus compatable instruments to respond to data received via the interface system.
- 5. SRQ (Service Request) - Used by instrument on the bus to indicate the need for attention and to request the interruption of current events.

2.7.2 Handshake

- 6. DAV (Data Valid) - Used by the controller or talker to indicate validity of data on the DIO lines.
- 7. NDAC (Not Data Accepted) - Indicates condition of acceptance of data on the DIO lines.

- 8. NRFD (Not Ready for Data) - Indicates condition of readiness to accept data on the DIO lines.

2.7.3 Data

- 9. DIO (Data Input/Output) - 8 data lines, carry the bus message in a bit parallel byte serial format.

3.0 Operation

3.1 Basic Operating Information

3.1.1 Power-On

When line power is turned on the MX will enter an initialization routine. The internal hardware will be configured, the attenuation and the attenuation step values will clear, the output will switch to standby mode, and the instrument's bus address will be displayed. Subsequently the instrument will enter local mode, enable interrupt requests, and start monitoring the front panel function keys.

3.1.2 Remote / Local Operation

In LOCAL mode all front panel controls are active and control the operation of the instrument. In REMOTE mode the instrument is controlled by the bus master. Front panel controls are disabled.

3.1.3 Local Mode

The MX functions as a stand alone noise generator. The noise output level is attenuated by the value programmed into the attenuator. The attenuator display displays this value in dB.

To enter a value into the attenuator press the A key. The LED above will verify selection, then enter the attenuation value on the numeric key pad with the most significant digit first. Upon completion of the sequence the LED will turn off.

Attenuation values from 00-99 dB in 1 dB steps (or 0.1 dB step with option) can be selected. The attenuator can be incremented or decremented by the attenuation step function. The (↓) key will increment the attenuator by the value stored in the step register. The (↑) key will decrement the attenuator by the same value. Step values from 00-99 dB or (0.0 - 99.9 with option) can be selected. To enter a value into the step register press the ENTER key. The LED above will verify the selection, then enter the step value on the numeric key pad with the most significant digit first. Upon completion of the sequence the LED will turn off. The step display shows the value programmed.

The output can be controlled by the NOISE 0 key. Each key closure forces the output to the opposite state. The STANDBY and NOISE indicators annunciate the noise output state. The NOISE state directs the noise signal to the output connector. The STANDBY state directs the noise signal to the internal load. The CLEAR / CANCEL key will clear the attenuation and the step values to 00 dB if there are no pending functions. A function will be cancelled if this key is pressed before a numeric value is entered on the key pad.

The numeric 0 key also functions as an address display key. The instrument's bus address will be displayed in decimal on the attenuation display when this key (0/MLA) is depressed provided no other functions are pending. The option function is selected through the numeric 1 key. To enter a function select code, press the (1/F) key. The LED

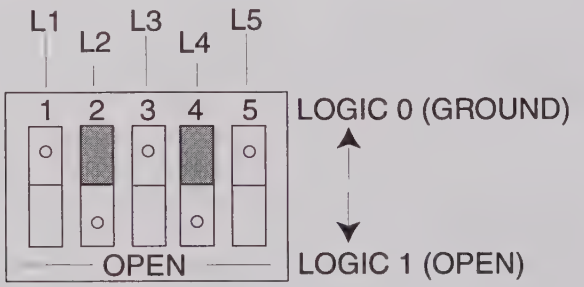
next to the function display will verify selection, then enter the option code between 0-9 on the numeric key pad. Upon completion of the sequence the LED will turn off and the selected option will be displayed on the option display.

3.1.4 Remote Configuration

The MX functions as a listener with the capability to be addressed and receive interface and device dependent messages via the GPIB. The programming configuration code as documented in IEEE-STD-488 is as follows: SH0, AH1, T0, L2, SR0, RL2, PPO, DC2, DT1, C0, E1.

3.1.5 Listen Address

The LISTEN ADDRESS of the instrument is set with five ADDRESS SWITCHES on the rear panel. Switch L1 is the least significant address bit. An address bit will have a logic value of 1 when the corresponding switch is in the open position. The switches in Fig. ?? are set to an address of * in the ASCII character set. Each instrument on the bus is assigned a unique address. The MX does not require any particular address and may be assigned any one of the 31 available addresses as long as system compatability is observed. Decimal 63 or octal 77 is reserved for the UNLISTEN command. If the instrument's address is changed after power on, a RESET sequence has to be initiated for the new address to be effective.



3.1.6 Remote Mode

To control the MX via the GPIB, the interface bus must be in remote (REN held true continuously), and the MX must receive its LISTEN ADDRESS with the ATN message true. In this mode the instrument responds to messages sent via the bus within the limitations of its configuration code. The DAV, NRFD, and NDAC signal lines effect the transfer of each byte of data from the bus to the MX. Messages received on the DATA lines with the ATN line true are interpreted as interface messages or commands. When the ATN line is false, messages received on the DATA lines are interpreted as device dependent. The IFC message received true will place the generator in its idle (LIDS) state. The EOI message received true will indicate to the MX the end of a multiple byte transfer. The instrument does not have a SRQ function. This message is sent passive false at all times. Refer to section 8 for remote control and programming. Refer to APPENDIX B for GPIB signal line definitions.

3.2 RF Circuits

3.2.1 Noise Module

The noise source and the amplifiers are housed in the same case designated as the noise module. Two basic case designs are utilized. A hot tin dipped cold rolled steel can or an iridited 2024-T4 aluminum can. The module is DC powered with the positive terminal employing an EMI filter to eliminate electromagnetic interference and internal resonances. The noise source provides white noise i.e. equal energy per cycle over the specified frequency band. In addition, the distribution of amplitudes of every frequency follows the Gaussian probability density function. The amplifiers are designed with a wide dynamic range to accommodate and amplify noise signals of large amplitudes. A narrow dynamic range will have a clipping effect and distrub the randomness of noise. To minimize this effect a large peak to rms ratio, or peak factor is implemented. The noise output power is rated over the specified band of each model.

3.2.2 Power Amplifier

Some models and the +30 dBm output option employ a separately constructed power module to amplify the noise power delivered by the noise module.

3.2.3 Programmable Attenuator

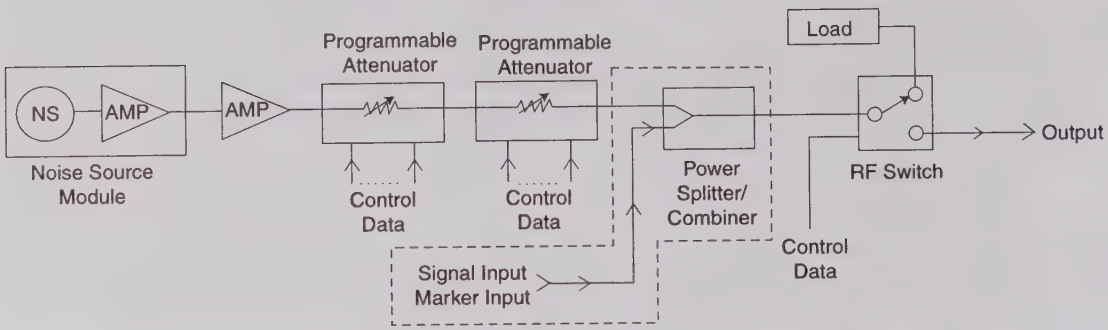
The attenuator is a rapid switching programmable step attenuator designed to operate in the DC - 2 GHz frequency range. It utilizes a microstrip construction using thick-film circuit elements and special compensation techniques to produce flat attenuation versus frequency characteristics. It consists of individual attenuation cells arranged in a binary sequence. Application of control voltage to a particular cell causes that cell to switch to the attenuate position. The attenuator is controlled either from the front panel or via the GPIB and inserts attenuation values from 00 to 99 dB in 1 dB steps or (00.0 - 99.9 in 0.1 dB step with option) into the RF path. Switching speed is approximately 6 msec maximum.

3.2.4 RF Switch

The RF switch is a 1 pole, 2 port latching type coaxial mini-switch with a frequency response of DC - 18 GHz. Switching between ports is accomplished by the application of a TTL level control signal. The latching property reduces the consumption to leakage levels after switching. Port selection is initiated either from the front panel NOISE 0 key or via the GPIB. In the STANDBY mode of the instrument the noise signal is routed to an internal load. In the NOISE mode of the instrument the noise signal is directed to the noise output connector. Isolation in STANDBY is 75 dB min. Switching speed is typically 6

msec. The RF switch directly drives the noise and standby indicator LED's through its circuitry. See block diagram below:

Drawing # 18208
RF Circuit Block Diagram



3.3 Digital Circuits and Wiring

With the exception of the noise generation and amplivication circuitry, all functions of the MX generator are controlled by a microprocessor unit (MPU). The MPU executes a monitor program stored in read-only memory (ROM), U8 and communicates with peripheral chips to perform a requested task. 1 k-byte of read/write memory (RAM) is available to store program segments and data. A peripheral interface adapter, (PIA-1), interfaces the MPU to the digital attenuator, the RF switch and the front panel display. The GPIB protocol is handled through a general purpose interface adapter, GPIA. Transceiver chips at the output of the GPIA insure compliance with the electrical specifications of the IEEE-488 bus. A second PIA providing 20 additional input/output lines is reserved for expansion.

The MPU, the memory chips, the peripheral adapters and required logic chips are concentrated on the main printed circuit board. Additionally the board includes a regulator circuit to generate the voltage level required to drive the digital attenuator cells. Integrated circuits U3 and U4 buffer the lower order address lines, the read/write (R/W) control line and the data bus. The two phase clock needed by the MPU is generated by U5. Machine cycle time is 1 microsecond.

The MPU does not have an independent input/output (I/O) structure and all peripheral chips are memory-mapped. PIA-1 (U9) and PIA-2 (U19) are addressed at 4000-4003 hex and 4004-4007 hex, respectively. The PIA's have 2 sets of 8 input/output lines (A and B ports) which can individually be programmed as inputs or outputs. Additionally 4 more control lines (CA and CB) are available from each PIA. The A port and control line CA2 of PIA-1 supply the display information to the front panel. The B port supplies the attenuator data at TTL voltage level. The high voltage driver chip U12 converts the TTL data to attenuator cell activation voltage which is +15 volts. CB2 is used as an output to control the RF switch.

The MX functions as a listener on the GPIB. A unique address is assigned to the instrument on the GPIB address selection switches located on the rear panel. On power-up and on RESET the switches are read by the MPU and the address of the instrument is stored in the GPIA. The GPIA constantly monitors the interface bus and interrupts the MPU whenever information has to be passed on for further processing. The handshade lines NRFD and NDAC are used to receive the information transmitted on the interface bus under sequential control. Transceiver chips U14-U17 insure compliance of all the interface lines with the electrical specifications of the IEEE-STD-488, 1978. A 24 position trapezoidal polarized connector located on the rear panel serves as the physical interface to the GPIB. Figure 6.1 shows the main circuit board schematic diagram of the instrument.

When the instrument is in local mode, the MPU scans the front-panel function keys. The keys are arranged in a 3 column * 6 row matrix. The MPU scans each column sequentially using address lines A2-A0. One address line at a time is brought low, and the rows are read for contact closure. If a closure is detected, the key is debounced in a software loop, and subsequently a routine is entered to process the desired task. The RESET and GTL (Go To Local) keys interrupt the MPU directly. The front panel numeric displays and the annunciator LED's are controlled by a single chip. The chip updates the front panel with the information stored in the on-chip registers. With the exception of the power on/off switch and the output connector, all front-panel controls, displays and associated chips are installed on the front-panel printed circuit board.

3.4 GPIB Connector Pin Configuration

The contact assignment of the GPIB connector is as follows:

Table 6: GPIB Connector Contact Assignment

Contact	Signal Line	Contact	Signal Line
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	GND 6
7	NRFD	19	GND 7
8	NDAC	20	GND 8
9	IFC	21	GND 9
10	SRQ	22	GND 10
11	ATN	23	GND 11

Table 6: GPIB Connector Contact Assignment

Contact	Signal Line	Contact	Signal Line
12	SHIELD	24	GND LOGIC

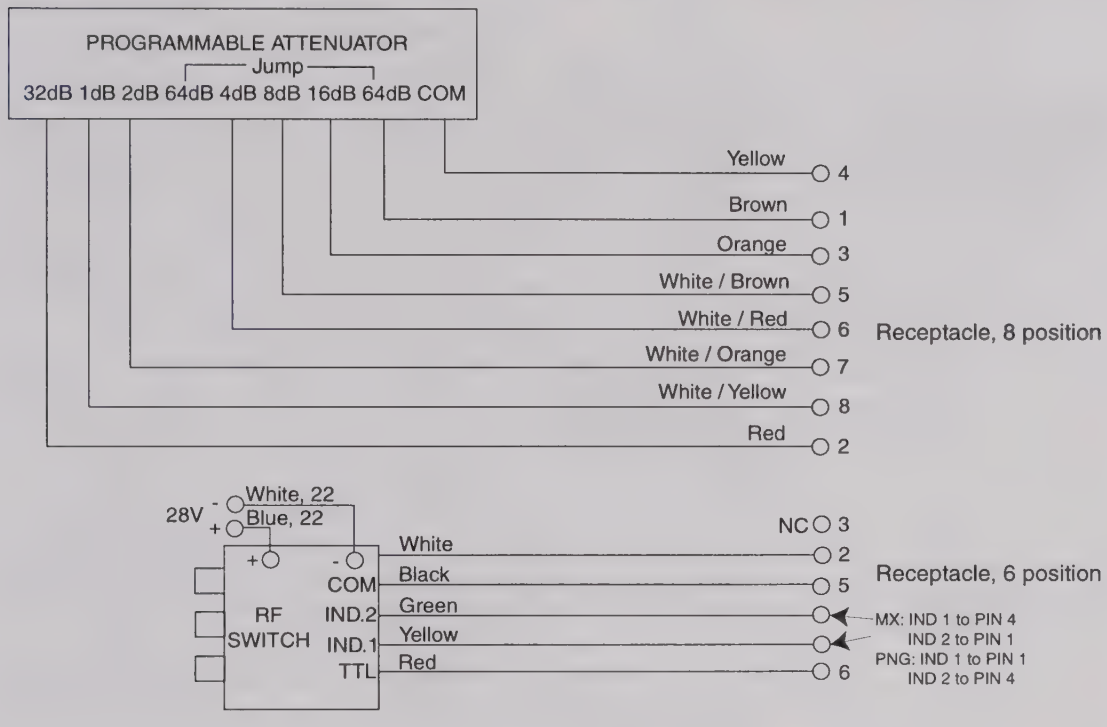
GND n refers to the signal ground return of the referenced contact. EOI and REN return on contact 24.

3.5 Wiring Diagrams

The front-panel PCB interfaces with the main PCB through a 28 pin header/receptacle pair, (HD2). The pin assignment is shown in Figure 6.2. Header/receptacle pair #3 and #4 interface the RF switch and the programmable attenuator to the main PCB, respectively. The wiring diagrams are shown in Figure 6.3. Header/receptacle pair #6 and #7 are reserved for expansion.

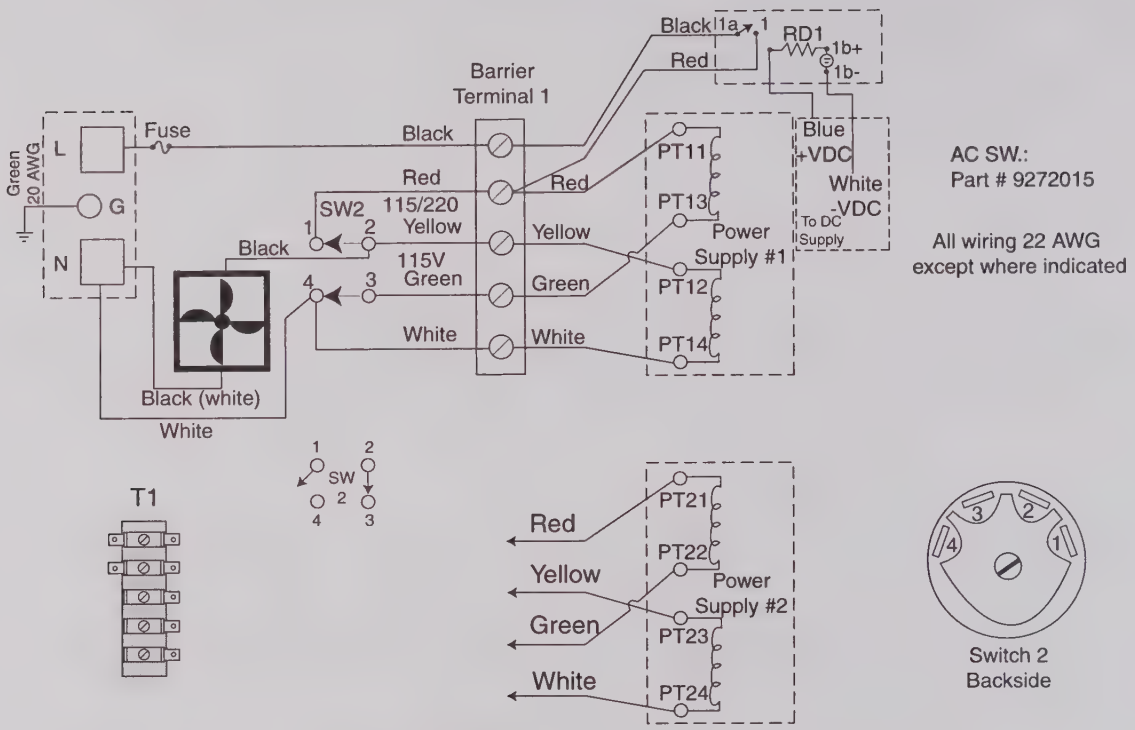
The noise generator is powered by 3 seperate voltage levels. The noise module, the amplifier module and Rf switch require + 28.0 volts. This voltage is supplied by power supply 2. The attenuator cell activation voltage is +15 volts ±5.0 volts. The regulator circuit on the main PCB supplies this level through the high voltage source driver, U12. The main and the front-panel PCBs are powered from +5.0 volts, supplied by power supply 1. The AC receptacle incorporates an RFI filter to reduce suseptibility of the instrument to interference conducted via the power line connection. Figures 6.4 through 6.6 show the AC wiring diagram, the DC wiring diagram and the regulator circuit schematic diagram, respectively.

3.5.1 Attenuator & RF Switch Wiring Diagram



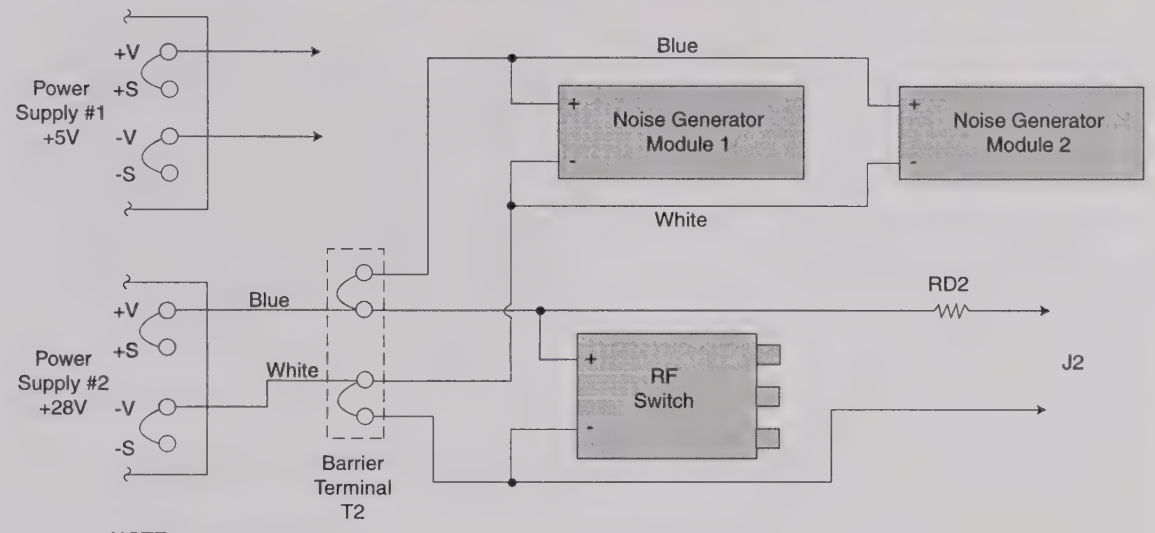
Drawing # 18485
Attenuator & RF Switch Wiring Diagram

3.5.2 AC Wiring Diagram



Drawing # 18481
MX AC Wiring Diagram

3.5.3 DC Wiring Diagram

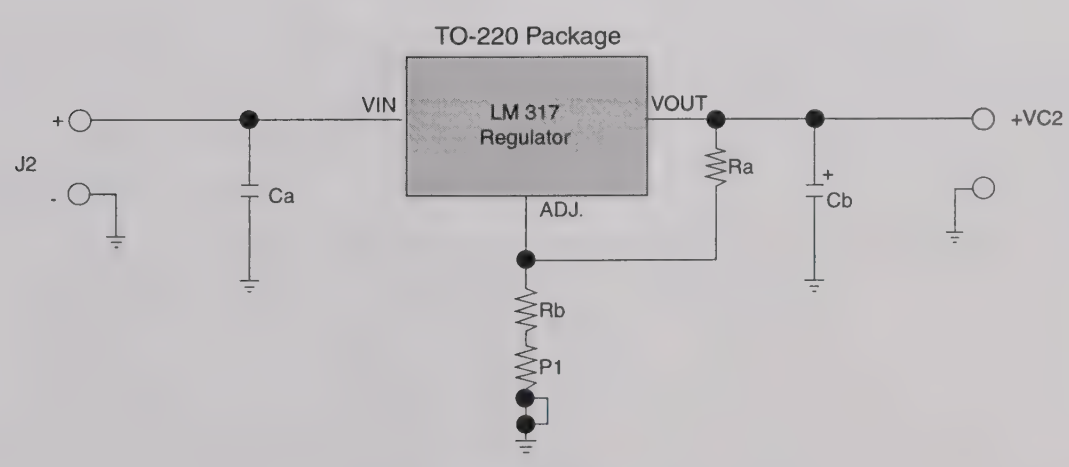


NOTE:
1. All wiring 22 AWG PVC except where indicated.

Drawing #18482
MX DC Wiring Diagram

3.5.4 Regulator Circuit Schematic Diagram

	Board 18339	Board 18247
Ra	R43	R20
Rb	R44	R21
Ca	C20	C19
Cb	C21	C20



Drawing # 18372
MX Regulator Circuit Schematic Diagram

4.0 Test Procedure

4.1 Equipment

- Spectrum Analyzer, Hewlett-Packard 8558B
- FFT Analyzer, Wavetek 5830A
- Power Meter, Hewlett-Packard 432A
- RF Millivoltmeter, Hewlett-Packard 3400A
- X - Y Recorder, Houston Instrument 100
- High Z AC Probe, Tektronix P6201
- Bandpass Filter, Wavetek 5200

The equipment may be substituded by suitable equivalents.

4.2 Test Procedure

Follow the manufacturer's instructions to calibrate the equipment used. The noise generator's output should be appropriately padded, if necessary, not to overdrive the test equipment's input.

4.2.1 Frequency Response

To test the frequency response and flatness of the noise generator set-up the equipment per figure 4.1. If a mismatch of impedances exists between the noise generator and the analyzer, terminate the generator's output with the proper load impedance and use a high impedance AC probe to couple the noise output to the analyzer. Examine the display and/or recording for noise level and flatness. The maximum flatness of each model is listed in Table 5-1.

4.2.2 Noise Output Power Measurements

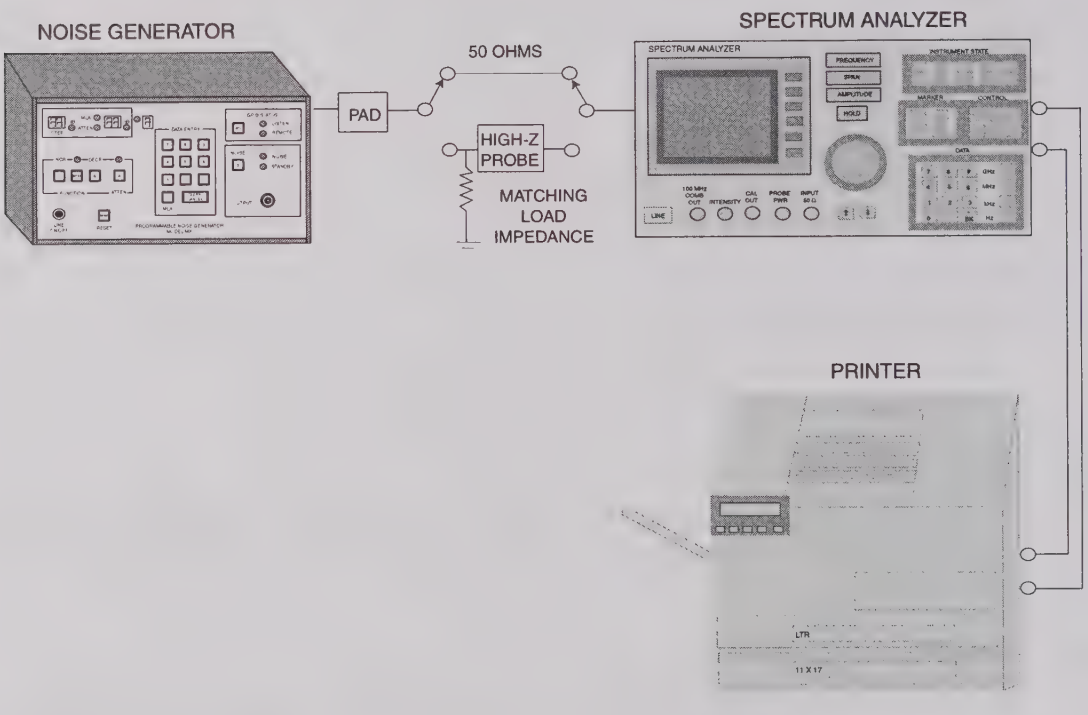
For noise output power measurements set-up the equipment per Figure 4.2. The bandpass filter is eliminated to make wideband measurements.

4.2.3 Output Power

The noise generator's output power is rated over the specified frequency band of each model. Output power can be normalized to the proper bandwidth using the procedure outlined in section 5.00.

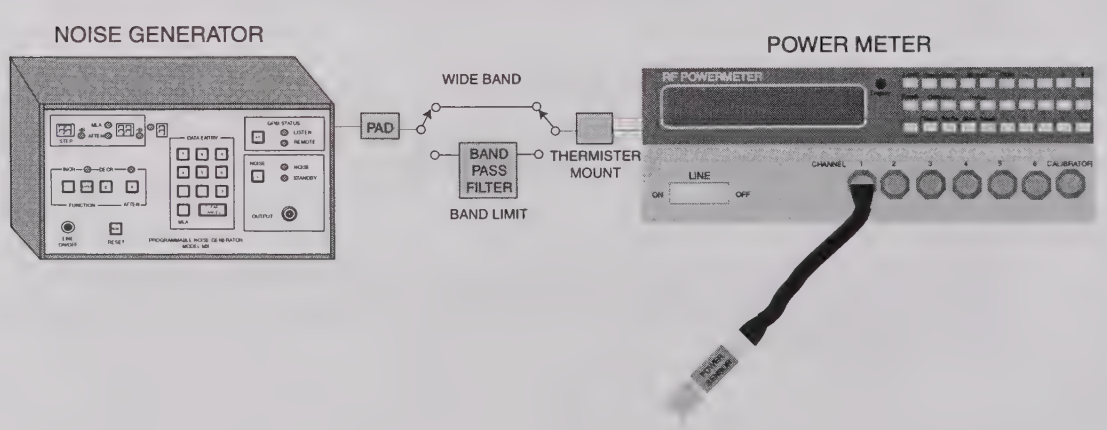
4.2.3.1 Test Circuit for Frequency Response and Flatness

Drawing # 18203
Test Circuit for Frequency Response and Flatness



4.2.3.2 Test Circuit for Power Measurement

Drawing # 18204
Test Circuit For Power Measurement



5.0 Noise Notes

Systems engineers spend considerable time and effort to eliminate unwanted electrical noise to permit accurate and unambiguous information handling by electronic equipment. However, increased knowledge of electrical noise reveals a structure which can be exploited for useful purposes. Electrical noise contains frequencies from less than 1 Hz to well over 100 GHz, thus noise generators provide broad bands of frequencies without resorting to many single frequency generators. In addition electrical noise is a source of randomly occuring pulses. The amplitudes of these pulses also vary randomly.

For practical applications, noise energy must be distributed evenly throughout a specified frequency band.

- WHITE NOISE: Random electrical noise displaying equal energy per cycle over a specified total frequency band.

- GAUSIAN NOISE: Random electrical noise that has an amplitude distribution which follows the Gaussian Probability Density Function. In mathematics, the limiting form for the distribution function of the sum of many independent quantities which may have differing distributions.

Noise power specifications are based on dBm / Hz available into a given load resistance at 290 deg K. Since noise varies with random motion of the free electrons, and noise power is proportional to a function of the bandwidth, noise power at temperature T is:

$$P=kTB$$

where k=Boltzmann's constant
T= absolute temperature, deg K
B= bandwidth
at 290 deg K; kTB=-174 dBm / Hz

The power output of a practical noise source is given in either of two ways:

- EXCESS NOISE: Noise power in dBm / Hz relative to thermal noise at 290 deg K.
- INTEGRATED NOISE: Noise power for a specified bandwidth relative to kT stated in dBm. To normalize the noise power to the proper noise bandwidth, the following correction factor is used:

$$10 \log (BW(1) / BW(2))$$

example; a signal is measured at -35 dBm / 12 kHz. To normalize this level to dBm / Hz the correction factor would be:

$$10 \log (12 \text{ KHz} / 1 \text{ Hz}) = 40.8 \text{ dB}$$

Hence, the normalized level is -35 dBm / 12 KHz - 40.8 dB = -75.8 dBm / Hz. To normalize to a wider bandwidth, the correction factor computed would be added to the measured level. The following table lists the output normalized to dBm / Hz for each model in the series.

It is assumed that the output of each unit is +10 dBm over the specified frequency range.

Table 7: Specific Model Frequencies and Outputs

Model	Frequency	Output (dBm / Hz)
MX 5101	10 Hz - 20 KHz	33
MX 5102	10 Hz - 100 KHz	40
MX 5103	10 Hz - 500 KHz	47
MX 5104	100 Hz - 3 MHz	55
MX 5105	100 Hz - 10 MHz	60
MX 5106	100 Hz - 25 MHz	64
MX 5107	100 Hz - 100 MHz	70
MX 5108	1 MHz - 300 MHz	75
MX 5109	30 MHz - 500 MHz	77
MX 5110	300 MHz - 1000 MHz	78
MX 5111	1 GHz - 2 GHz	80
MX 5200	100 Hz - 1 GHz	80
MX 5250	100 Hz - 1500 MHz	82

REFERENCES:

1. Aldert VanDerZiel, Noise; Source Characterization Measurements
2. Dr. Lon Edwards, Desirable Electrical Noise
3. Hewlitt-Packard, App. Note: 150-4

6.0 Replacement Parts

This section contains information on replaceable parts by description, designation and model / part number. Parts can be ordered from Micronetics Wireless, Inc. or suitable replacement may be used.

Table 8: Parts List

Description	Designation	Model / Part Number
MAJOR PARTS		
Enclosure		170712-21-XP
Power supply	#1	5 volts @ 3.0 A
Power supply	#2	28 volts @ 1.0 A
Noise module		Instrument Model
Power module		Instrument Model
Attenuator		3200-1 or 50 MDA127-592
RF switch		RMS-2D-I-L-TTL
Line cord		531
Front panel	18465	
Power on/off switch		616-6-1-A1H
Noise output connector		1132-6001
Display filters		MX-SCR65
Rear panel	18468	
AC receptacle		HPCA-3L
Colt Selector switch	SW2	SWA-033.4501
Fuse holder		FEU-031.1653
Fan		W2s075-aa-11-02
Fan guard		9480-2-4039
GPIB connector		57-20240
GPIB hardware		552633-3
Address switch		76SB05
Address switch PCB		276-24

Table 8: Parts List

Description	Designation	Model / Part Number
Address PCB spacer		18556
Main PCB		18247
Resistor	R1	3 KΩ, 1/4 W
Resistors	R2-R4, R6-R-17	4.7 KΩ, 1/4 W
Resistor	R5	1 KΩ, 1/4 W
Resistor	R20	220 Ω, 1/4W
Resistor	R21	2.7 KΩ, 1/4W
Potentiometer	P1	82 PAR1K, 1 KΩ
Capacitor	C1-C7, C9-C15	0.1 µF, 50V, MLC
Capacitor	C8	0.01 µf, 50V, Cer Disk
Capacitor	C16	150 pf, 50V, Cer Disk
Capacitor	C17	4.7 µf, 20V, Tantalum
Capacitor	C18	100 µf, 16V, A1 E1
Capacitor	C19, C21	0.1 µf, 35V, MLC
Inductor	L1	10 µH, Q55 @ 7.9 MHz
Diode	D1	1N914
Regulator	VR1	LM317T
Heatsink		PA1 - 1CB
Crystal	X-Tal	113-31, 4 MHz
HEADERS		
2 pos	J1, J2	350209-1
6 pos	HD3	3-87515-4
8 pos	Hd4-HD6	3-87515-5
10 pos	HD1	87589-1
24 pos	GPIB	87589-8
28 pos	HD2	1-87589-0

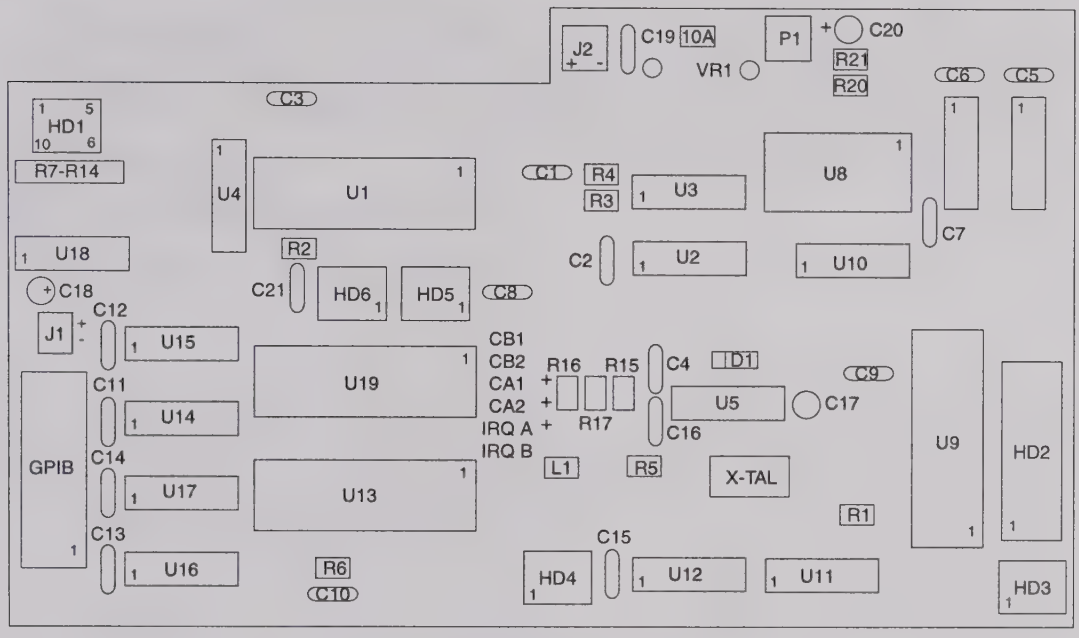
Table 8: Parts List

Description	Designation	Model / Part Number
INTEGRATED CIRCUITS		
IC1	MPU	MC6800
IC2	U2	74LS138
IC3	U3	74LS365
IC4	U4	74LS245
IC5	U5	MC6875
IC6, IC7	U6, U7	2114
IC8	U8	2732 A
IC9	PIA-1	MC6821
IC10	U10	74LS00
IC11	U11	74LS244
IC12	U12	UDN2981, UDN2982
IC13	GPIA	MC68488
IC14 - IC17	U14 - U17	MC3448A
IC18	U18	74LS244
IC19	PIA-2	MC6821
Main PCB Spacer		18622
Front Panel PCB		18321
Resistors	R1 - R10	4.7k Ω, 1/4W
Resistor	R11	200 Ω, 1/4W
Capacitor	C1	10 µf, 20V, Tantalum
Capacitors	C2, C3	0.1 µf, 50V, Cer Disc
Capacitor	C4	0.01 µf, 50V, Cer Disc
Key switches	GTL, RESET	T5C-M-OC
Key switches	All Others	T5C-M-NO
LED	Red	SOLR-312
LED	Green, IND2	SOLG-322

Table 8: Parts List

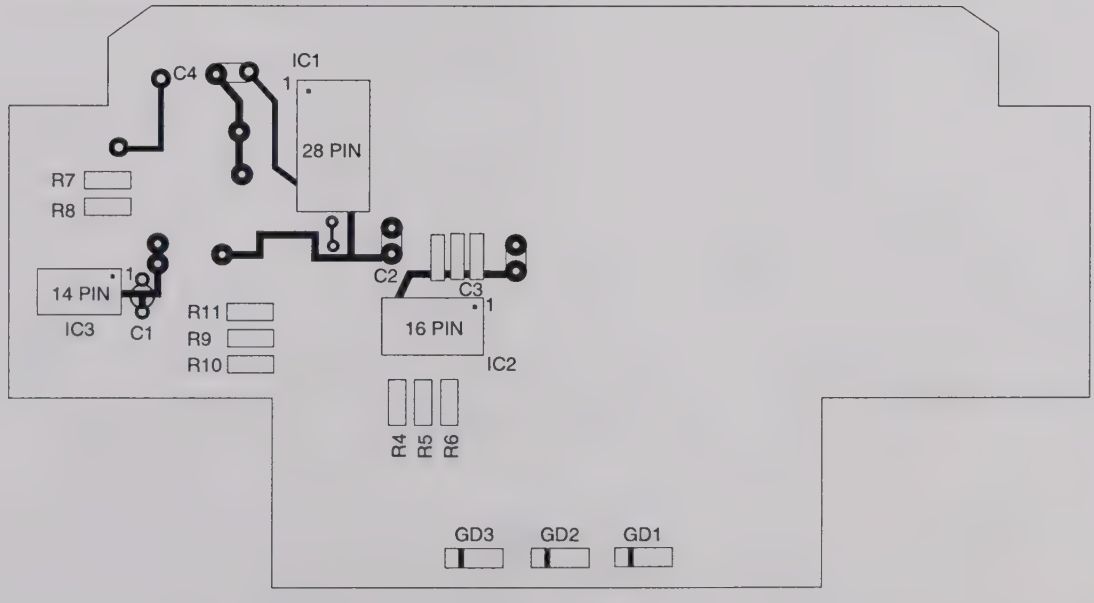
Description	Designation	Model / Part Number
LED	Yellow, IND1	SOLY-342
LED spacer		18529
Display, 7 seg	Dig1 - Dig4, Dig 8	5082-7610
Elevator sockets		14-8xxx3-10C
Diodes	GD1 - GD3	1N3592
IC1		ICM7218C
IC2		74LS365
IC3		74LS00
Header 28 pos		1-87589-0
Front PCB Spacer		18468
RECEPTACLES		
2 pos	P1, P2	1-480318-0
26 pos	R3	87631-2
28 pos	R4 - R6	87631-4
10 pos	R1	87631-6
24 pos	GPIB	3-87977-7
28 pos	R2	1-87977-2
28 pos	Front panel	3-87977-9
Contacts	P1, P2	60617-4
Contacts	R1 - R6, GPIB	87667-3
Dummy Load		T170M
RF Cables		510-494-xx
Barrier Terminal	T1	71105-1212-1213
Barrier Terminal	T2	71102-1212-1213
Crimp Terminal		RAD1823
Card Guide		WEL6375

6.1 MX 5000 Circuit Board Layout



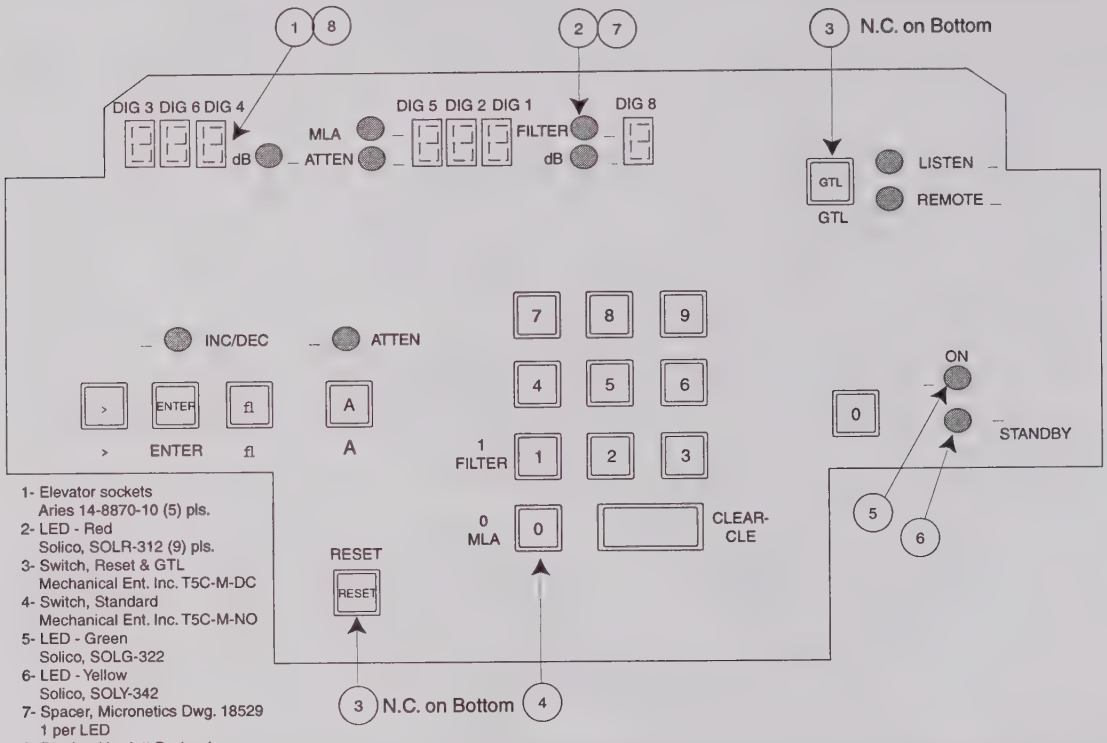
Drawing # 18645
MX 5000 CIRCUIT BOARD LAYOUT

6.2 MX 5000 Front Panel Circuit Board Layout (Back Side)



Drawing # 18560
MX 5000 Series, Front Panel Circuit Board Parts Layout (Back Side)

6.3 MX 5000 Front Panel Circuit Board Layout (Front)



1- Elevator sockets
Aries 14-8870-10 (5) pls.
2- LED - Red
Solico, SOLR-312 (9) pls.
3- Switch, Reset & GTL
Mechanical Ent. Inc. T5C-M-DC
4- Switch, Standard
Mechanical Ent. Inc. T5C-M-NO
5- LED - Green
Solico, SOLG-322
6- LED - Yellow
Solico, SOLY-342
7- Spacer, Micronetics Dwg. 18529
1 per LED
8- Display, Hewlett Packard
5082-7610 (5) pls.

Drawing # 18560
MX 5000 Series, Front Panel Circuit Board Parts Layout (Front)

7.0 Programming

The MX-5000 Series generator is designated to execute instructions sent to it via the GPIB. All instructions are sent as ASCII characters and in capital letters. Instructions are partitioned into two functional areas as interface functions and device dependent functions.

7.1 Device Dependent Functions

The format of the messages in this functional area are as follows:

Command Character Data Data END

The following command characters are used to control the various device functions of the noise generator. Most command characters are succeeded by 1 or 2 numeric data characters. The format will be referred to as a sequence. Throughout the discussion a space is shown within a sequence for clarity only and should not be included in the transmission. However a space is permissable in between sequences.

Attenuation: A x1 x2 x3
A attenuation command character
x1 most significant digit; 0-9
x2 least significant digit; 0-9
x3 least significant digit; 0-9 (0.1 dB step only)

Attenuation Step: S x1 x2 x3
S attenuation step command character
x1 most significant digit; 0-9
x2 least significant digit; 0-9
x3 least significant digit; 0-9 (0.1 dB step only)

Output Control: O x3
O output command character
x3=0; output standby
x3=1; output on
x3=2; output toggle, used in delay loop only.

Attenuation Increment: I x 4
I increment command character
x4=Space

Attenuation Decrement: D x 4
D decrement command character
x4=Space

Trigger Mode: T x5
T trigger mode command character
x5=0; execute immediately on END
x5=1; execute on GET
x5=2; start DELAY LOOP immediately on END
x5=3; start DELAY LOOP on GET

GET; group execute trigger
END; EOI or carriage return CR

Delay Multiplier: W x1 x2
W delay multiplier command character
x1 most significant digit;0-9
x2 least significant digit;0-9

Program Segment: P x6
P program segment command character
x6=0-7 & 9

Recall Segment: R x7
R recall segment command character
x7=0-7 & 9
x7=9 reserved for software reset

Termination Character (END): CR; carriage return

A device dependent message can be up to 32 characters long. This is done by concatening of the individual command sequences and terminating the multibyte sequence with the END character.

The trigger mode T x5 selects between the different operating modes of the noise generator. T0 is the default mode and is entered on power-up or on reset. In T0 device dependent messages will execute as soon as an END character is received. In trigger mode T1, the instrument will defer execution of the device dependent messages until a group execute trigger, GET is received. In tripper modes T2 and T3, the instrument will cycle through a loop until interrupted. Mode T2 starts immediately on END, while T3 defers execution until a GET command is received. To select the trigger mode the sequence T x5 is sent as the first two characters of the multibyte message.

The noise output level is varied by programming attenuation values. With the attenuator set at 00 dB maximum, output is delivered. The A x1 x2 sequence will attenuate the output level by x1 x2 dB. Hence an attenuation range from 00 dB (max output) to 99 dB (min output); in 1 dB steps; can be programmed. Attenuation values of less than 10 dB are to be sent with x1=0.

The attenuation step function is used to store the attenuation step value in the step register. The S x1 x2 sequence programs the step value from 00 dB to 99 dB. The increment I x4, or the decrement D x4 messages increment, decrement the attenuation by the attenuation step value, respectively. Total attenuation is limited to 99 dB, and the instrument will stop incrementing at 99 dB, and decrementing at 00 dB. The default state of the instrument is to increment the attenuator.

The output command sequence O x3 will put the instrument into standby, on or toggle states depending on the value of x3. In the standby state noise power is routed to an internal load. In the on state, noise power is delivered to the ouput connector. The toggle state is effective in the delay loop only, and the output will assume the opposite state with every pass through the loop.

Trigger modes T2 and T3 are associated with a programmable loop which is executed until interrupted. The loop provides the following capabilities:

- Turn output on. Increment attenuation by the step value using the programmed delay between increments until 99 dB of attenuation is reached. Reset attenuation to initial value. Start over.
- Turn output on. Decrement attenuation by the step value using the programmed delay between increments until 00 dB of attenuation is reached. Reset attenuation to initial value. Start over.
- Toggle the output using the programmed delay.
- Combine c with a or b. In this case the output is toggled using the programmed delay after each new value of attenuation.

A unit delay is approximately 0.7 seconds. The W x1 x2 sequence multiplies the unit delay by x1 x2 where x1 x2 is treated as an 8 bit hex number, and can assume a value of up to 99 hex, 153 decimal. Maximum delay is limited to approximately 1.8 minutes.

The P x6 sequence is used to store up to eight 32 character program segments in the instrument's memory. This would normally be done before the start of a test session. To program a segment, change the trigger mode to T0, then send P followed by the segment number x6 in the range of 0-7. Following this sequence send the program segment to be stored. For example: T0 P0 A56 S01 O2 W50 CR would program segment #0 for 56 dB of attenuation, 1 dB of incremental step, output toggle mode with 50 units of delay time. This program would be used with the T2 or T3 trigger modes.

The R x7 sequence is used to recall stored segments for execution. Segment R9 is reserved for a software reset routine. When a program segment is recalled the current trigger mode is effective. To change the trigger mode, precede the R x7 sequence with the trigger mode sequence. For example, T2 R0 CR will recall the program segment stored at segment #0 in the previous example and execute it as a loop immediately.

A few programming examples:

T0 A09 S05 O1 CR	: Execute immediately. Attenuation 9 dB, attenuation step 5 dB. Output on.
I Space CR	: Increment attenuation by 5 dB. Step value was specified in the previous step.
O0 CR	: Output standby.
T1 A25 O1 CR	: Program attenuation for 25 dB. Program output for on. Defer execution of command until GET received.
T2 A150 S050 I O2 W01 CR	: Start delay loop. Attenuation initial value 15 dB.

Attenuation incremental step 5 dB.
Output toggle mode.
Delay 0.7 seconds.

Execution is as follows:

- Attenuate output by 15.0 dB
- Turn output on, wait 0.7 seconds.
- Turn output off, wait 0.7 seconds.
- Increment attenuation by 5 dB.
- Turn output on, wait 0.7 seconds.

This cycle repeats until 99 dB of attenuation is reached, at which time the attenuator is initialized to 15 dB and the loop is restarted. Any transmission will interrupt the loop.

7.2 Interface Functions

Interface commands are sent as a single ASCII character without termination. The following commands are recognized and acted upon as described below.

MLA	: Listen Command
UNL	: Unlisten Command
DCL	: Device Clear
GTL	: Go to Local
GET	: Group Execute Trigger

MLA: The MX noise generator's bus address is assigned by the address switches located on the rear panel. Any one of the available 31 listen addresses can be assigned to the instrument. If the address is changed after the instrument has powered up, a reset has to be executed for the new address to be valid. When the instrument receives it's bus address, it will go into remote mode, provided the remote enable line REN of the bus is true. All front panel controls except for RESET and GTL are disabled, and the instrument is ready to execute remote interface messages.

UNL: Universal unlisten command. The instrument will clear the listen state and only universal commands will be recognized.

DCL: This command resets the attenuation, and the attenuation step values to 00 dB, switches the output to standby state, initializes the trigger mode to T0, and clears all pending data and pending error condition, and awaits new instructions.

GTL: Returns the generator to local mode where all the front panel controls are functional.

GET: Used in conjunction with trigger modes T1 and T3. This command will start execution of a device dependent message(s) which were programmed previously but deferred.

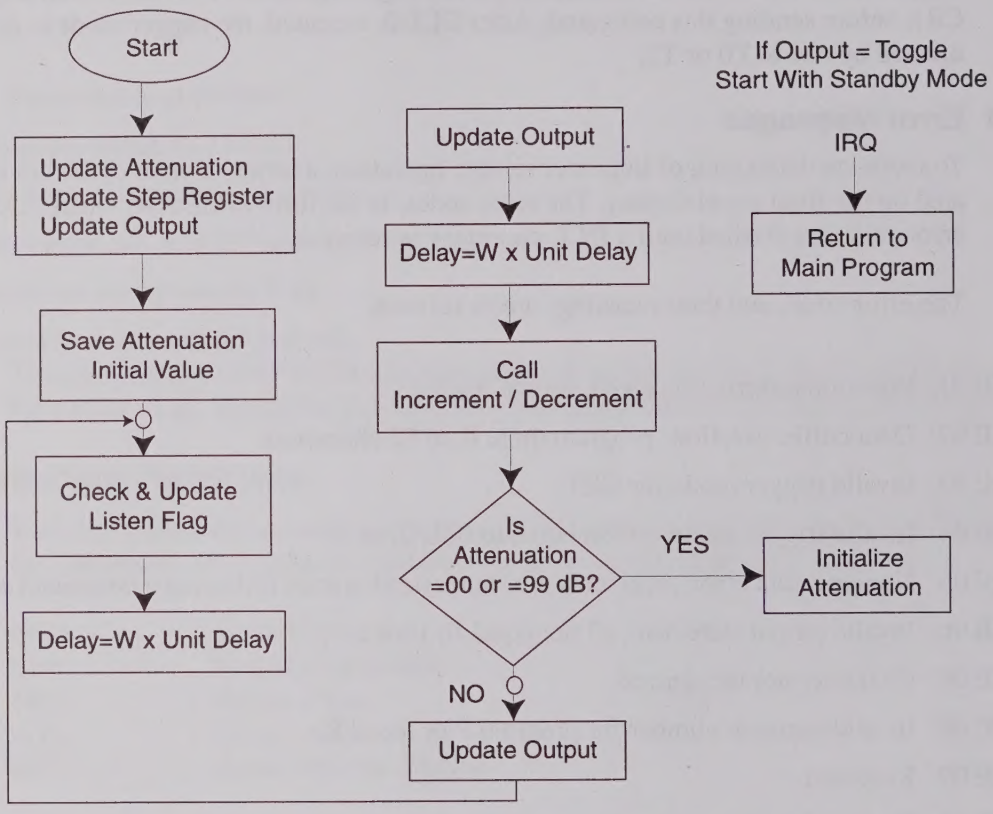
For this command to execute properly, the trigger mode has to be a T1 or T3. Update the trigger mode within the device dependent message sequence; (T x5 additional sequences CR); before sending this command. After GET is executed, the trigger mode is decremented by one to T0 or T2.

7.2.1 Error Messages

To facilitate debugging of improper remote operation, a series of error codes are annunciated on the front panel display. The error codes, in the form of EE XX, where XX is the error code, are flashed until a DCL command is received.

The error codes and their meanings are as follows:

- EE 01: Phantom interrupt received, source invalid.
- EE 02: Data buffer overflow, program more than 32 characters.
- EE 03: Invalid trigger mode for GET.
- EE 04: Invalid trigger mode, x5 not equal to 0, 1, 2, or 3.
- EE 05: Numeric data error, received a non-numeric character following a command character.
- EE 06: Invalid output state date, x3 not equal 0, 1, or 2.
- EE 07: Character not recognized.
- EE 08: Invalid segment number for program P or recall R.
- EE 09: Reserved.
- EE 10: Reserved.
- EE 11: Internal RAM Tests.
- EE 12: Internal ROM Tests.
- EE 13: Reserved Internal Tests.



Flow chart; MX Generator T2, T3 Trigger Modes